with tabular statements of the number of passengers conveyed, the receipts, the number of miles traversed by the locomotive engines, and the paper was illustrated by a large collection of maps, sections of the line, and drawings of the construction of all the bridges and other works of the line.

The paper is a valuable addition to the effects of the institution, and reflected the highest credit upon its author, for the skill displayed in the conduct of the works, and for the able and candid manner in which he has described it.

A description was then read of the mode adopted at the Montrose Harbour for driving piles by steam power. This machine, which could not be well understood without a drawing, was described by Mr. James Milne, who had used it, and was the author of the paper, as being very efficacious, and having done its work rapidly and well. In the discussion which ensued, Mr. Rendel, under whose directions it had been used, approved fully of it, and it appeared to be the unanimous opinion that it was generally applicable to engineering work, particularly as piles can be driven either very rapidly with a light ram in sand or in silty ground, or with a heavy ram and a low fall in hard ground, and that the pile-heads would be rarely injured by it.

The papers announced to be read at the meeting of April 21, were:—

No. 678. "Account of a series of Experiments on the comparative strength of Solid and Hollow Axles," by C. Geach.

No. 667. "An account of the Scaffolding used in erecting the Nelson Column, Trafalgar-square," by T. Grissel, Assoc. Inst. C.E.

No. 680. "Description of the system of Scaffolding employed at Paris for the repairs of Public Buildings, Obeliska, Chimneys, &c., and of the Machine for raising Building Materials, in use at the Houses of Parliament and other Buildings," by Pierre Jousnit.

No. 577. "Description of the Method employed for Repairing a Chimney, 120 feet high, at Messrs. Cowper's Cotton-mills, Glasgow," by J. Colthurst, Grad. Inst. C.E.

ELEMENTARY ESSAY ON MORTAR AND CEMENTS.

BY JAMES WYLSON, MEM. SOC. S.A.A.D.

DEFINITIONS.—1. MORTAR is the compound employed to unite the masonry or brick work of buildings erected in dry situations into a hard, compact, and tenacious mass—its ordinary constituents being lime and sand, and the former essential in all cases. CEMENT is a composition similar to mortar, which is adapted for and used in the construction of such works as are wholly and constantly wet or damp, or are so circumstanced as to be alternately moist and dry. These names and definitions would be sufficiently distinctive were there not some other terms unavoidably in use, which, if no reference were here made to them, would seem vague and even somewhat conflicting in their meaning, and, perhaps, tend to perplex. Mortar and Cement are the proper denominations of two separate classes; but among the limes employed in composing the former, there are some which, though they do not possess the peculiar attribute of the cement-stones so strongly as to be qualified for fulfilling their use, unaided by,the admixture of other ingredients, yet have that property to so important a degree, when so combined, as fully to justify the distinctions of *Common lime* and *Water-lime*, as well as the consequent ones of *Common mortar* and *Aquatic* or *Hydraulic mortar*. The phrase *Water-cement* is also used, and might appear ambiguous, were it not explained that besides the way in which the term "cement" is applied in reference to subaqueous construction, it is the designation given to a number of compositions for uniting substances which, though accessaries in architecture, are merely decorative, or of a character too delicate to be classed with building-materials. The meaning of this nomenclature being thus preliminarily indicated, the reader can proceed without further guidance.

2. As the ingredients in these compositions are exceedingly various, both as to kind and quality, and their different properties involve a diversity of proportions, it is absolutely necessary that we be familiar with them before undertaking to practise their use; however subordinate and unimportant the daily seeing them mixed up by unskilful labourers may make the subject appear.

3. LIME is the product obtained by the calcination of calcareous substances, namely, such as contain *calx*, or lime—combined with carbonic acid; and which abound in a variety of forms in the earth's crust as well as on its surface—including marble, alabaster, many building-stones, basalt, spar, chalk, shells, coral, &c. These, however, do not afford an equal supply of lime, neither is that which is obtained from them of an identical nature: limestones, for example, are seldom pure, that is, composed solely of lime, but usually contain one or more foreign matters, such as granules of *quartz, silica, silex, argil* or alumina, *magnesia, manganese, iron, bitumen*, &c.; and how far the limestones are suited to the purposes of the builder depends upon the presence or absence, and the relative proportions, of these adjuncts, in the various combinations in which they occur. Limes which contain silica are frequently termed *siliceous*; when comprising silex or flinty sand, *silty, sandy*, or *arenaceous*; magnesia, *magnesian*; manganese, *manganesian*; bitumen, *bituminous*; alumina, *clayey, argillaceous*, or *aluminous*; and iron, *ferruginous*. The most pure generally burn to the whitest lime, and are suitable only for mortar; the argillo-ferruginous kinds are dark when burnt, and are those possessing the invaluable property of hardening under water.

4. Limestone may readily be distinguished from sandstone, and other non-calcareous rocks, by placing a small piece in a glass, covering it with water, and adding a little of almost any acid; the latter combines with the lime and expels the carbonic acid, causing it to rise to the surface, more or less briskly, in bubbles of effervescence: this is a ready and unfailing test. It may also be scratched with an iron point.

5. BURNING.—Limes are not efficacious in their natural state, but must be burnt to render them available for the composition of mortar; and they are of a very infusible nature; the purpose of the calcination is to dispel the carbonic acid associated with the lime; for the reason that the latter will not combine with water if the former is present. To effect this separation thoroughly—on which the goodness of the lime so much depends—requires a red heat; for although the greater portion of the acid is readily expelled, its disengagement being facilitated by the earthy matters contained in the limestone, the latest lingering remains are tenacious and not easily evolved. The more compact limestones of course require the longer continuation of the burning. When the acid has been slowly driven off, the limestone or chalk has lost about 3/10ths, or 44 per cent. of its weight, and, whatever may have been its colour before burning, has changed more or less to a dun or buff hue with that operation. Attempts have been made to form a cement by burning old mortar, but without any success. It is understood that the goodness of lime does not depend on the hardness of the stone from which it is obtained, as was long supposed. As the disunion of the acid begins on the exterior of the lumps of limestone, gradually progressing to the centre, it is evident that they should be as small as is compatible with the cost of fuel and of breaking them into smaller fragments. Manganese gives to lime a brown colour when burnt: a deep brown or red colour *before*, and a yellowish hue *after* burning, generally denotes the presence of iron; siliceous limestone gives a buff colour; silex renders it, before burning, sufficiently hard to scratch glass, and presents its effervescing freely on the application of acid. This substance is so far changed in its nature by calcination as to dissolve in acids, which it does not before undergoing that operation. Magnesia also causes lime to effervesce, but very slowly, and gives to the acid a milky appearance; in hot acid, however, it effervesces as vigorously as common limestone. Some of these substances combine with the lime in burning, and thus give to it properties which it had not before that operation.

6. An easy test whereby to judge at the kiln whether lime is sufficiently burnt, is to withdraw some from the midst, and drop a piece about the size of a pea into a glass containing some dilute muriatic acid—if perfectly calcined there can be no effervescence, but if not, it is sure to present that phenomenon in some degree.

7. The white, granular, or *statuary* marble furnishes, when sufficiently calcined, the purest lime of all the calcareous stones, containing sometimes only a very little silicious earth; on analysation it has been found to contain 44 per cent. of lime, 33 of carbonic acid, and 3 of water. It is this which the chemist employs when a lime of superior purity is required; although the lime is but rarely made use of in the arts, because the stone falls into a granular powder when heated, thus rendering the ordinary lime-kiln unsuitable for its due preparation; a paste made of it and placed in a humid situation will not harden. Plymouth marble is also very pure, and, indeed, furnishes lime almost identical with that of common chalk; like the statuary, it is not at all adapted for a water cement; but for the construction as well as finishing of common buildings, in dry situations, it is sufficiently good. The plentiful shell-marble of Derbyshire affords lime of a very superior description for common mortar; but compared with the Barrow lime of Leicestershire, it is inferior for subaqueous purposes; it is of a good colour, slakes well, and does not discolour masonry. In some places on the Continent, where marble is abundant, it is extensively used for lime, and its quality is said to be excellent.

8. GYPSUM (the sulphate of lime in chemistry), or, as it is more generally called, PLASTER OF PARIS, is a species of alabaster, dug at the village of Montmartre, near that city, and, indeed, abounding in its vicinity; it is used there to a considerable extent as lime mortar; but for building it is much inferior to the latter, being liable to decay with age, and its durability depending on its total exemption from damp; it is also rather plentiful in our own country in Nottinghamshire, Staffordshire, Derbyshire, and other parts; and it has been stated that the best and most expensive that is used in Paris is from Newark, in the first-mentioned county. Its principal use for buildings is in interior plastering, with its moulded work and enrichments. Immediately before use it is reduced to a thin paste with water, and it sets and hardens very quickly, slightly swelling at the same time; if made too thin, however, it is apt to continue of a light and friable structure.

9. It is rendered fit for the purposes to which it is applied by calcination, and grinding or pounding. Its quality is said to be judged of by taking up a handful, the good being known by its retaining the impression of the fingers, and the bad by running through them like fine sand. It is only acted on by sulphuric acid, in its natural state.

10. There is a very superior and valuable species of gypsum used in the island of Minorca, called GUARAN; with which partitions of stones, on edge, and only 3 or 4 inches thick, are built, so powerful is its cementing property. Like plaster of Paris, however, it must not be exposed to wet, which soon softens it to a pulp. For use, the powder is mixed with water to a fluid state. It sets almost instantly, and acquires a hardness like that of marble.

11. The Kentish-rag, Portland, Purbeck, Painswick, and Bath stones, all afford lime of very good quality; those which are hardest and most durable as building-stones, furnishing limes of relative corresponding value in these respects. Kentish-rag, which is the hardest, supplies, when properly calcined, a lime approaching in quality the Barrow lime.

12. Oolite is one of the purer sorts of lime, and therefore white when burnt. Its natural formation is an aggregate of small round grains resembling the eggs of fish, and from which appearance originates its name.

13. Grey limestone is of a slightly scaly tendency, but compact, hard, and rather difficult to quarry: it takes considerable time and quantity of fuel in burning, and becomes a white lime: the darkest calcines whitest. It contains very little foreign matter, and not exceeding five per cent. of clay and sand.

14. Swinestones (called by the French *Pierre Puante*, and by the Germans *Stink-stein*,) are so denominated on account of the fetid odour they emit on being rubbed against any hard body, and which is computed to that of a pigsty, Harrowgate-water, or rotten eggs: it is attributed to the presence of sulphur of hydrogen. These stones, which include the different black marbles, may be deprived of their carbonic acid at a lower heat, and in a shorter